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SECTION II—GENERAL METEOROLOGY.

NEW ENGLAND SNOWFALL.[1]

By CHARLES F. BROOKS, Ph. D.

[Dated: Yale University, New Haven, Conn., Apr. 5, 1917.]

The heavy snowfall of the winter 1915–16 in New England has occasioned renewed interest in the subject of previous snowy winters and of the factors controlling the average distribution of snowfall. In spite of the fact that the total depth of snowfall over most of New England was from 6 to more than 8 feet in that winter there have been much snowier seasons (e. g., 1716–17 and 1786–87) since the beginning of the eighteenth century. Some of the great storms of northeastern Massachusetts are interestingly recorded by Sidney Perley.[2] In the winter of 1716–17 snow accumulated to the depth of "10 to 15 feet on the level." The season of 1740–41 was not only severe in temperature but also very snowy. Two storms in one week of December, 1786, brought the depth of snow on the ground near Boston up to perhaps 6 feet if not more. In the eighteenth century there were apparently two other winters when the total snowfall in northeastern Massachusetts exceeded 6 feet—1747–48 and 1798–99.[3] In the nineteenth century at least four winters in this region had more than 6 feet of snowfall—1801–1802, 1856–57,[4] 1873–74, and 1898–99. Furthermore, in the present century there have already been two such winters in northeastern Massachusetts, 1903–4 and 1915–16.

Thanks to Sidney Perley's compilations and to the records of the Signal Service and Weather Bureau at Boston, it has been easy to make this rough comparison of the history of snowy winters of the past two or three centuries. It would appear that the tremendous New England winters of long ago were no more numerous, and, with at least two exceptions, perhaps no more snowy than some in the present century. The extreme snowiness of 1716–17 and 1786–87 rests largely on the snowfalls of two weeks with two snowstorms each.

A real "old-fashioned snowstorm" is characteristically described as one in which roads and fences were obliterated, or communications by road blocked for days, and such that many people needed to make tunnels through the drifts to get out of their houses at the ground floor. In addition, the experiences of men lost in the snow and of vessels blown on shore are commonly mentioned. Meteorologically this means an intense coastal cyclone with a northerly gale and snow falling for a day and a half or more to an average depth exceeding 3 feet. In northeastern Massachusetts there seem to have been only 7 such storms in more than 200 years, these 7 occurring in but 5 of the 12 very snowy winters of the same period. In Boston since Signal Service records began in 1871 the measurements show no month with more than 3 feet of snowfall.

An important feature of New England snowstorms is their local character. The account of snowy winters and great snowstorms for northeastern Massachusetts does not agree with the history of snowfalls in other parts of New England. For instance, in the New Bedford region since the middle of the eighteenth century the most famous three snowstorms seem to have been those of December 26–27, 1778, December, 1786, and January 15–16, 1831.[5] In southern Connecticut the snowstorms of February, 1717, were extreme, and that of March 11–14, 1888, has left a strong impression on the people. Winslow Upton says,[6] "The great prominence given to the storm under consideration was due to the fact that the form of the precipitation was snow, and that it fell in the vicinity of New York, causing almost a complete suspension for several days of the railway traffic centering in that city." Everett Hayden[7] shows that 135 schooners and 81 other vessels were lost along the middle and north Atlantic coast of the United States during this storm. His monograph contains an excellent set of colored weather maps. Snow fell for about 2½ days and the depth in southwestern New England and eastern New York was estimated at 2½ to 4 feet on the level, the greater depths being along the Hudson and on the windward or western slope of the Berkshires, the southern Green Mountains, and in central Connecticut. Snowdrifts with a maximum depth of 15 to 40 feet were reported. (See fig. 3, map from Upton.)

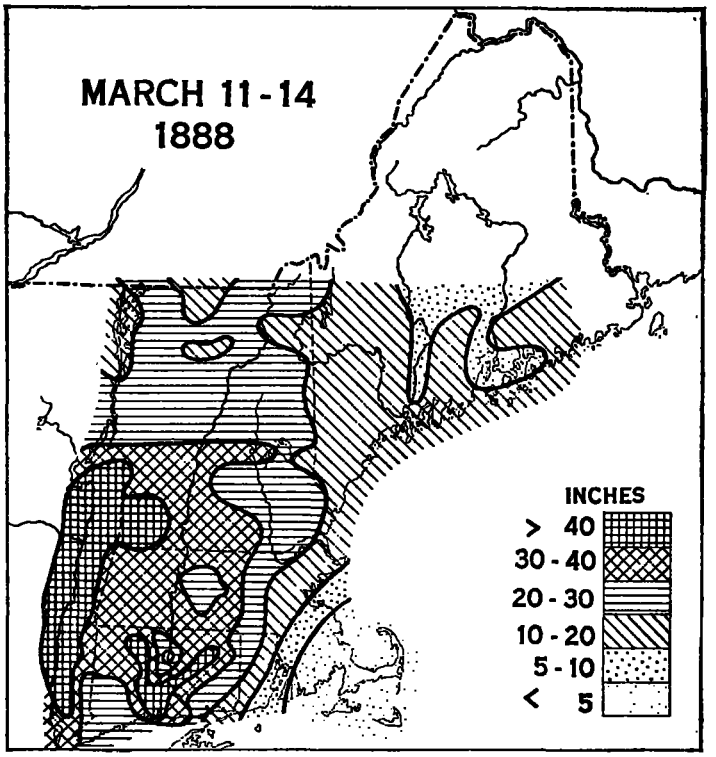

FIG. 3.—Snowfall of the storm of March 11–14, 1888 (after W. Upton, Am. metl. jour.) [Am. geogr. soc.].

On account of the local character of snowstorms, the snowfall of months and even of the individual seasons is

[1] Amplified by the author from the article under the same title in The Geographical Review, March, 1917, published by the American Geographical Society, New York, N. Y. The Weather Bureau would here acknowledge its indebtedness to the American Geographical Society, Isaiah Bowman, Director, for permission to reengrave figures 1, 3, 4, 6, 7, 9, 10, 11, 13, 14, 16, 17, 19, 20, 21, 23, 24, 26, and 30, from the original drawings prepared by that society.

[2] *Perley, Sidney.* Historic storms of New England. Salem, Mass., 1891. 341 p. 8°.

[3] *Perley*, op. cit., pp. 31–36, 51, 54, 124–125, 153.

[4] *Perley*, op. cit., pp. 161 and 323–328.

[5] See a sheet published by *Thomas R. Rodman*, New Bedford, Mass., Mar. 4, 1902.

[6] *Upton, Winslow*, Amer. met'l. jour., May, 1888, 5:19–37.

[7] U. S. Hydrographic office: Nautical Monographs, No. 5. Washington, 1888. 65 pp. 6 pl. 4°.

often quite different at places not far apart, as is illustrated by the data in Table 1.

TABLE 1.—*Seasons with more than 66 inches of snowfall measured at Boston or New Haven.*

Winter.	New Haven	Boston.
	Inches.	*Inches.*
1873–74	68.8	96.4
1880–81	69.5	53.8
1886–87	46.2	73.0
1887–88	66.2	41.2
1892–93	74.2	67.3
1896–97	67.4	43.2
1898–99	66.4	71.1
1903–04	42.7	73.1
1906–07	64.3	67.9
1915–16	a 76.0	a 79.2

a Since Jan. 1, 1909, regular Weather Bureau stations have measured sleet separately. Thus if sleet were included, the total for New Haven would be 82.3 instead of 76 inches.

It is evident from the scattered examples just mentioned that "old-fashioned snowstorms" are not phenomena of the past. Four feet of snow in one storm seems to be the maximum which can be expected in southern New England. Only on one occasion, February 18-22, 1717, was there apparently as much as 6 feet. From a comparison of the duration and amount of snowfall it is apparent that snow usually does not fall at a rate exceeding 1 inch an hour. Upton [8] published a table showing the rate of precipitation near the maximum area in the storm of March, 1888. At New Haven, where the snowfall was estimated at 42 inches and the equivalent depth of water content, 4.50 inches, in other words, about 10:1, the precipitation rates per hour were as follows:

	Inch
Mar. 11, 10 p.m. to 12th, 7 a.m.	0.10
Mar. 12, 7 a.m. to 12th, 3 p.m	0.1
Mar. 12, 3 p.m. to 12th, 10 p.m.	0.1
Mar. 12, 10 p.m. to 13th, 7 a.m.	0.07

In southern New England special meteorological conditions favorable for long-continued snowfall may very rarely bring a fall of snow amounting to as much as 6 feet locally, and if repeated after an interval of a day or two may result in as much as 10 feet within the limits of one week. This happened 200 years ago and was closely approximated in a 5- or 6-day storm of snow and sleet 115 years ago (1802).[9] If one of our modern snowstorms should last four days instead of two or three southern New England in this century might have a great snowstorm equal to that of 1802 or 1717.

Heavy New England snowstorms have occurred with a number of combinations of weather conditions. A cyclone over the Great Lakes and another off the south Atlantic coast may unite south of New England and move thence northeastward. This combination makes a strong cyclone south of New England so that the cold northerly winds and the moist easterly ones combine to produce the requisite low temperature and moisture. Such was the case in the Portland storm of November 26-27, 1898. When a previously formed snow cover is present, the cold air and the consequent tendency for an anticyclone to stick over New England serve to intensify and delay the cyclone. A good example of this may be seen on the weather maps for the last week in March, 1916, when an anticyclone stayed over snow-covered New England, delaying and forcing to the south a cyclone approaching from the west.[10] Blue Hill Observatory records [11] show that, in general the greater the number of days with snow on the ground in a winter month (December to March) the lower is the temperature relative to the mean. Furthermore, in months with long-enduring snow cover, there are the greatest inversions of temperature between the top of the hill and the valley station 600 feet below. With an average depth of 26 inches of snow on the ground on February 15, 1899, simultaneous temperatures at the top of the hill and in the valley were 8°F. and −20°, respectively, the greatest difference recorded there up to that time. [12] [13]

The other common type of cyclonic arrangement favoring New England's northeast snowstorms involves a single cyclone which fights its way up the coast against the southward circulation on the east side of a great anticyclone lying dormant over the intensely cold, snow-covered ground. The snowstorms of January 18–19, 1857, and February 11–14, 1899, are examples.[14] In addition, any combination which results in the passage of a strong cyclone immediately south of, or northward through, New England, while an anticyclone on the northeast or north is in the way, favors the occurrence of heavy snowfall if the temperature is low enough. In March, 1888, an anticyclone following the passage of a cyclone north of New England, entered New England on the west just as a southern low center was approaching the south shore. The difference in temperature, which at one time was 25 degrees F. in 75 miles, favored the development of a strong cyclone, while the wind circulation and southeastward tendency of the anticyclone prevented the normal northeastward movement of the cyclone.

Snowy winters, while sometimes taking their character from a single storm, are generally the result of the passage of a number of cyclones south of or through New England. Cold winters are more snowy in southern than in northern New England, while warm winters may lead to excessive snowfall in northern New England by reason of greater moisture in the air (compare 1915–16 with 1900–1901, as shown in figs. 24 and 26 on pp. 282, 283). As the winter 1915–16 was, for southern New England in general, the snowiest in more than 40 years, and was exceeded over a wide area perhaps only twice in two centuries, the meteorological conditions producing it may give some indication as to the immediate cause of such snowy winters. In the three snowy months, December, February, and March, the North Atlantic cyclone was stronger than usual, particularly so in the very snowy March.[15] In the summers of 1915 and 1916 the ice in the Greenland Sea was abnormally extensive.[16] Also, in the summers of 1786 and 1787 the ice off the east coast of Greenland was so extensive that at 65° N. latitude Danish ships could not approach closer than 50 miles to the coast in July or 10 miles in August, 1786, while the closest approach in

[8] Amer. met'l. jour., 1888, 5:36.

[9] *Perley*, op. cit., p. 161.

[10] "Weather forecasting in the United States" (W. B. No. 583, 1916), pp. 107, 133, 139. *See also Köppen, W.* Verhältniss von Frost, Schneedecke, etc., im Winter 1906-07. Meteorol. Ztschr., 1907, 24: 323-325.

[11] Annals, Astron. obs'y. Harvard College, Cambridge, ...

[12] *These results from Blue Hill data were obtained largely by the class in climatology* at Yale College in 1916.

[13] *Voeikov* has fully discussed the effect of a snow-cover, in his paper "Der Einfluss einer Schneedecke auf Boden, Klima und Wetter," Wien, 1889 (Penck's Geogr. Abhdl., v. 3, no. 3) which was reviewed in the Amer. met'l. jour., 1890, 7:332-336.

A more recent paper on the subject is by *O. V. Johansson*, Dämpfende Wirkungen des Schnee und Eises auf die Lufttemperatur. Öfversigt, Finska Vetensk. Soc. Forh., Aft. A, 1912-13, 60, no. 11. 64 p.

[14] Maps of isobars and isotherms for Feb. 12, 13, 14, 1899, are published in "Weather forecasting in the United States" (W. B. No. 583) as figs. 114, 115, 116.

Maps of the snowfall day by day for that period are published in this REVIEW, June, 1914, 42: 319-324 as figs. 1 to 6, inclusive, illustrating *C. F. Brooks* "Distribution of snowfall in cyclones of the eastern United States," ibid.

The weather map for a type of heavy snow over southern New England is illustrated by that for Dec. 22, 1908. (See fig. 163 of "Weather forecasting," supra.)

[15] *Brooks, C. F.* World-wide changes of temperature. Geograph. review, New York, Oct. 1916, 2: 249-255.

The temperature of the Gulf Stream water southeast of Nantucket was about 2 degrees (F.) above normal in March, 1916.

[16] *See* Spitsbergen ice conditions, 1915 and 1916. *C. I. H. Speerschneider* in Denmark, Meteorologisk aarbog, 1916. Nature, London, Feb. 8, 1917, pp. 454-455; *also* Geographical review, New York, Oct. 1916, 2: 307, 310.

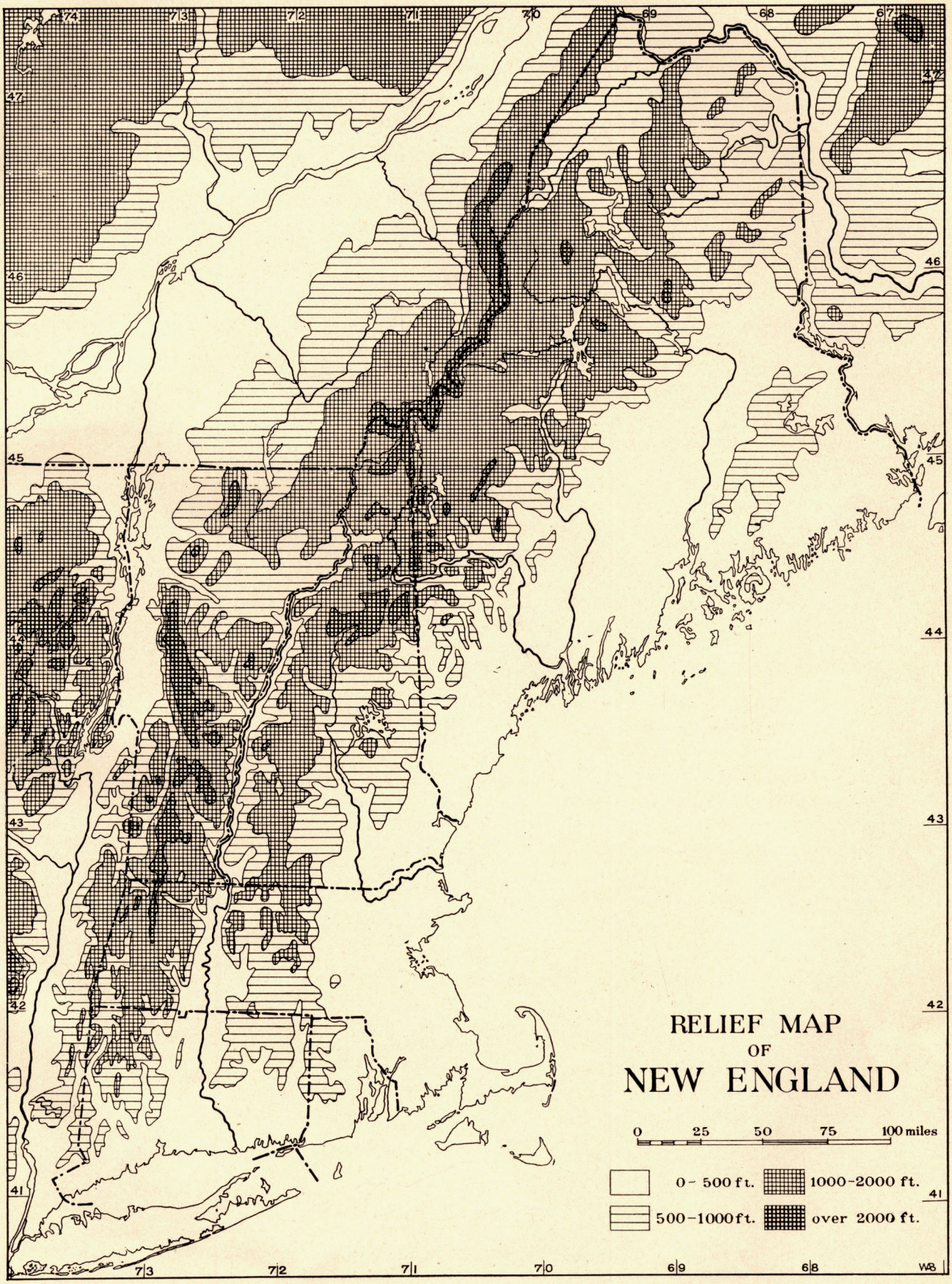

FIG. 1.—Relief map of New England. Scale, 1:3,500,000. [Am. geogr. soc.]

In New England the contours are based on the current edition of the U. S. Geological Survey contour map of the United States, 1:2,500,000; in Canada, on J. G. Bartholomew's Orographical Map of the St. Lawrence Basin, 1:5,000,000, accompanying S. E. Dawson's "The St. Lawrence Basin and Its Borderlands," London, 1905.

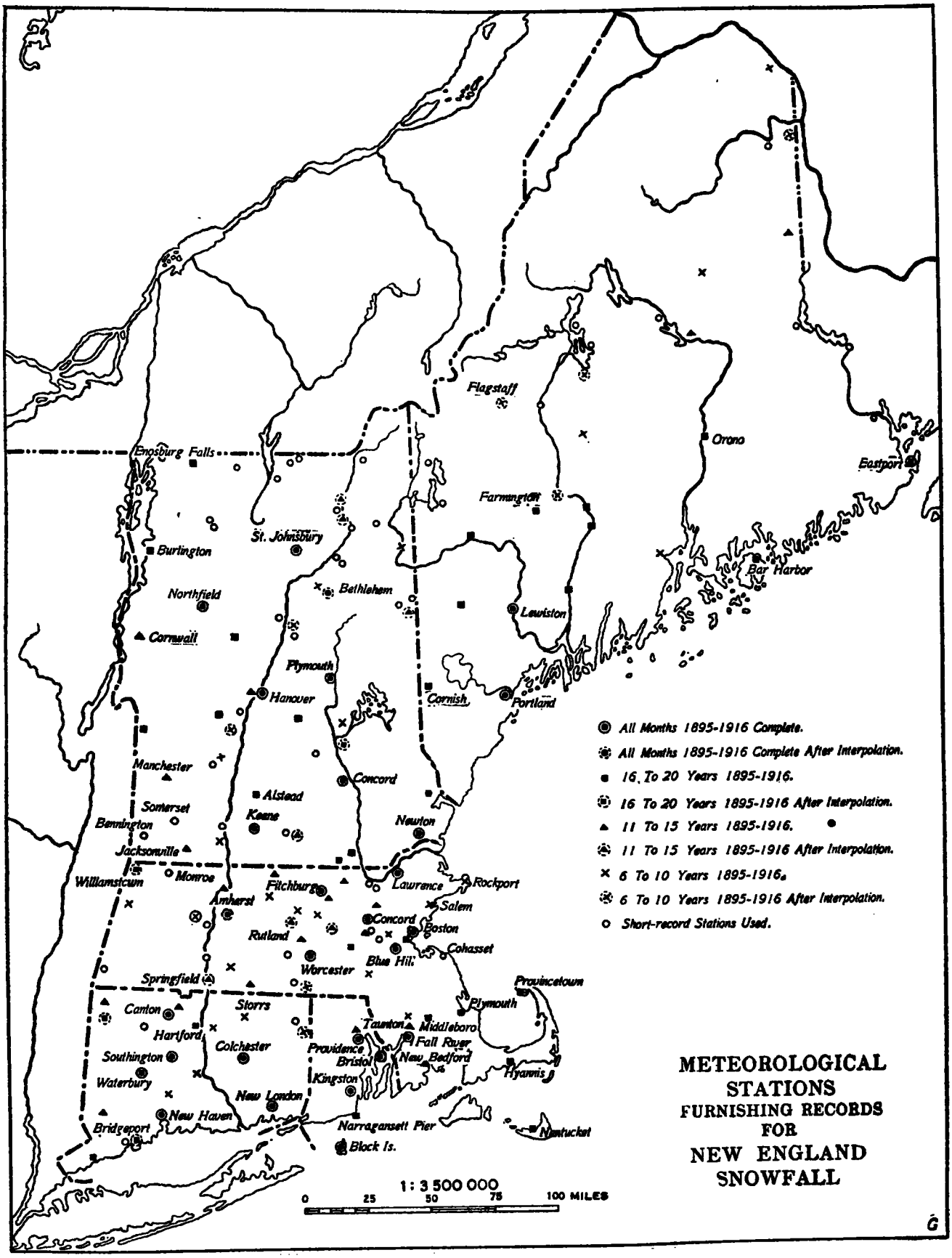

FIG. 2.—Map of New England showing location of stations and characters of the respective records used in preparing figs. 3-30, inclusive.

1787 was 30 miles.[17] In snowiness the intervening winter in New England was much like that of 1915–16.

In the summer of 1716 none (possibly one) of the 153 Hamburg and Bremen whalers in the Greenland Sea was lost, while the average losses each summer between 1697 and 1719 were four; the season of 1700 was the only other one without losses.[18] This might indicate an open season whose warmth, if continued into the following winter, would strengthen the Iceland cyclone.

In the cold, snowy summer of 1816 there was an unusually strong subpermanent cyclone in the Greenland Sea and accompanying (perhaps only coincident) cold northwest winds in New England. The following is an abstract of Perley's extensive account of that summer in New England.[19]

Summer of 1816.—The coldest summer known to have been experienced in New England was that of 1816. Some have spoken of it as the year of "eighteen hundred and froze to death." There were frost and snow in all the summer months. Near Manchester, N. H., there was an ice storm on May 24. Snow was reported in Ohio on the 22d. On June 5 the temperature rose to 88° at Chester, N. H., but the next morning ice formed to a thickness of an eighth of an inch on bodies of standing water. In a cold squally west wind, snow fell in Vermont, Massachusetts, New Hampshire, and Maine on June 6, 7, and 8. The depth of snow was sufficient to cover the ground even at Newton and Salem, Mass., while in the western mountains it collected to depths of more than a foot. Frost on the 9th, 10th, and 11th of the same month killed vegetation in northern New England and western Massachusetts, and occurred on two mornings at Salem. June 22, 23, and 24 were very hot in Salem, the successive maximum temperatures reported being 93°, 101°, and 100°F. In July northern New England experienced frosts which did considerable damage to crops, and at Amherst, near Manchester, N. H., snow fell. In Massachusetts, however, July was a warm month. In August there was frost; snow fell on the hills west of Manchester and whitened the mountains in Vermont. On September 11, 2 or 3 inches of snow fell at Springfield, Mass., followed by snow at Boston and at the mouth of the Kennebec before the close of the month. The season as a whole had been very dry, particularly in Vermont. In Connecticut and Rhode Island the weather had not been extreme. The season was somewhat backward, but the crops were not so materially affected as they were farther north.

In Greenland Sea Scoresby found this summer of 1816 to be more open than usual, with higher temperature, more wet days in May and June, and a lower pressure than had been the case in any but one or two of ten summers.[20]

TABLE 2.—*Weather of May and June, 1916, in North Greenland Sea west of Spitsbergen (Scoresby).*

Element.	Month.	Means.	Departures.	Relation to other extremes.
Temperature.	May....	24.6° F....	1.8° above 12-year average...	1808 and 1817 warmer.
	June...	33.9° F....	2.6° above 10-year average...	1813 warmer.
Pressure....	May....	29.84 inches	0.07° below 12-year average..	1808 and 1813 lower.
	June...	29.81 inches	0.06° below 10-year average..	No other June so low, 1809–1818.
Winds.....	May....	SE. to S..	Winds usually north in May.	
	June...	SW.....	Winds usually north in June.	

[17] *Scoresby, William, jr.* Account of the arctic regions, etc. ——. 1820. v. 1, pp. 3, 69.
[18] *Zordrager, C. G.* Grönländische Fischerei und Wallfischfang. Leipzig, 1723. pp. 370, 376.
[19] *Perley.* Historic storms, etc., pp. 204–213.
[20] *Scoresby, William, jr.* op. cit., vol. 1, app. 1.

As sharp contrasts in temperature make strong cyclones, it is not inconsistent to say that both excessive ice conditions and unusual openness of the waters north of Iceland may bring about or accompany intense "Iceland" or North Atlantic subpermanent cyclones, for a strong temperature gradient occurs somewhere under either condition. Such a gradient may be produced over the western Atlantic by abnormal warmth of the Gulf Stream there, as in the winter of 1915–16. These citations are mere suggestions as to the way in which snowy winters of New England may be explained and perhaps later forecasted. Obviously the proof awaits the study of a series of years' observations of Northern Hemisphere weather.

MONTHLY AND SEASONAL SNOWFALLS.

In spite of its small area the snowfall of New England differs greatly in different parts, such inequalities being due primarily to latitude, altitude, and exposure. New England snowfall may be considered in two divisions: The western and northern mountainous section, and the lower coastal region. In the mountains the greater the altitude the heavier is the snowfall, as a general rule. While the temperature control of latitude and altitude on snowfall is important, the exposure to snow-bringing winds and the proximity of water surfaces to windward cannot be overlooked. For example, the Green Mountains become progressively snowier southward on account of more open exposure to moist easterly winds from the Atlantic.[21] (See discussion of fig. 15, map for February, 1899, p. 278–9.)

Heavy snowfall on one side of a range of mountains or hills is accompanied by light snowfall on the other side, for any winds after losing moisture on one side arrive as warming drier winds on the other. Mountains cast shadows in the sunlight, and just as truly they cast "snow shadows" in the snow-bearing winds. The Champlain Valley is in the "snow shadows" of both the Green Mountains and the Adirondacks, and so is a region of relatively small snowfall. The least snowfall in Vermont, except in the extreme southwest, occurs at Burlington behind the highest part of the Adirondacks on the west and the White and Green Mountains on the east. The upper Connecticut Valley is similarly affected.

On the immediate coast winds blowing freely off the ocean are chilled and made to yield up some of their moisture as they lose velocity and rise over the land. If the wind is previously at a temperature just below freezing it may swirl onto the land in clouds of dense snow. In general, it is cold enough for snowy ocean winds only in February, March, and April.[22] Inland a little way, if the land were flat, a belt of maximum snowfall would soon be reached, for it is here that the wind behind is most crowding against and piling over the lower wind, which is retarded by friction. Perhaps this is why Hyannis has more snowfall than Rockport, Provincetown, and Nantucket.

Where for some distance inland the country is rising, the zone of maximum snowfall is farther from the shore and the snowfall is more intense because of the heavy precipitation produced at lower temperatures. Such is the case some 40 miles inland in western Maine and eastern Massachusetts. Beyond the crests of the divide the snowfall decreases somewhat, but not so rapidly as

[21] Evidences of local glaciation on the east side of the Green Mountains in southern Vermont were described by G. D. Hubbard at December, 1916, meeting of Assoc. Amer. Geographers. Ann., Assoc. Amer. Geogr., 1916, 6. Cf. Wilmington, Vt., topog. sheet, U. S. Geol. Surv.
[22] *Brooks, C. F.* Snowfall of the eastern United States. MO'LY WEATH. REV., Jan. 1915, 43: pp. 5, 9, and 10; figs. 4, 6, 8, and 10, on pp. 6 and 7.

toward the warm ocean. Thus, in south central Maine, the upper Merrimac Valley, the lower Connecticut Valley, and eastern Rhode Island, the snowfall is appreciably less than in the but slightly higher region on the east. Other factors which lead to the decreased snowfall of inland valleys are the weaker cyclonic action and the usual higher temperatures at the lower elevations.

Some snowfall comes with westerly winds, thus at times reversing the side of the divide on which snow is at its maximum. The snowfall distribution of coastal New England is not unlike that of the mountains. In this case, the immediate shore, even when flat, has somewhat the effect of a range of hills—when the temperature is low enough the snowfall near the shore is heavy, and snow-shadow areas are developed behind, especially in the valleys.

DATA.

In preparing the accompanying maps, all the readily available published snowfall data for the period 1895–1916 were used. These data were taken from the monthly reports of the New England weather service, the MONTHLY WEATHER REVIEW, and the monthly report "Climatological Data for the New England Section." The maps of average snowfall are based on the records from 178 stations, many of the short-period records being combined, when close together, or used to fill in deficiencies of the longer records from near-by stations. Of course, the foundations for the lines were the 29 complete records of the 21 seasons. Other records were divided into the three groups designated on the base map (fig. 2): 16 to 20 years, 11 to 15, and 6 to 10. A few records of less than six years were used on the basis of ratios derived from the longer records of near-by stations having the same general exposure.

TABLE 3.—*Extent of snowfall data, 1895–1916 (see fig. 2).*

States.	All stations with any reports.	Number used in making averages.	Averages put on map of seasonal snowfall (fig. 30).				
			21 years.	16–20 years.	11–15 years.	6–10 years.	Total.
Maine	47	32	3	9	2	4	18
Coordinated*					1	4	5
New Hampshire	38	31	5	5	0	3	13
Coordinated			1	1	3	1	6
Vermont	31	27	2	5	3	2	12
Coordinated					1	1	2
Massachusetts	93	58	7	7	8	10	32
Coordinated			1	2	3	2	8
Rhode Island	8	7	4	1	1	0	6
Connecticut	28	23	6	2	3	4	15
Coordinated				2		1	3
Total	245	178	29	34	25	32	120

*The coordinated records are those pieced together from two or more neighboring stations.

This table shows the minimum available for all the months; for each month the data are more extensive. They appear sufficient to allow a fairly accurate mapping of the distribution of snowfall. The addition of three years of records and of the short ones for filling has changed the aspect of the average snowfall shown on the maps already published; but the alterations are in details, and follow the principles indicated by the earlier maps.[23] These features stand out all the more clearly with the removal of some of the minor irregularities due to shortness of period and lack of stations. The errors of snowfall measurement are so great at times that it is only the accordance of results at stations similarly located which justifies making maps of "snowfall."[24] The probable error of these averages from the true mean (if there were such a thing) is large. For instance, as computed by Fechner's formula, $E=\frac{1.1955}{(2n-1)^{\frac{1}{2}}}\times v$, where v is the mean departure from the average and n the number of years, the probable error, E, of the 21-year seasonal average at Eastport, Me., is 4 per cent, and that at Enosburg Falls, Vt., 5 per cent.[25] In spite of these errors the following maps consistently uphold one another in illustrating the broad principles already mentioned.

THE MAPS.

For the months May to October, inclusive, no maps are published here, for except in the mountains the snowfall of these months is negligible. Snowfall in May is nowhere a rarity except on Cape Cod, where none has been observed in at least 21 years. In June, July, and August, 1816,[26] snow fell in New England and even on the coast of Massachusetts. There have been occasional snows in these months on the mountains since then. September snow is common in the north and not very rare south even to the central highlands of Massachusetts. In October during the past 21 years snow has fallen throughout New England. Average amounts in excess of 1 inch are encountered in the White Mountains, and on the east flank of the Green Mountains.

November snowfalls.

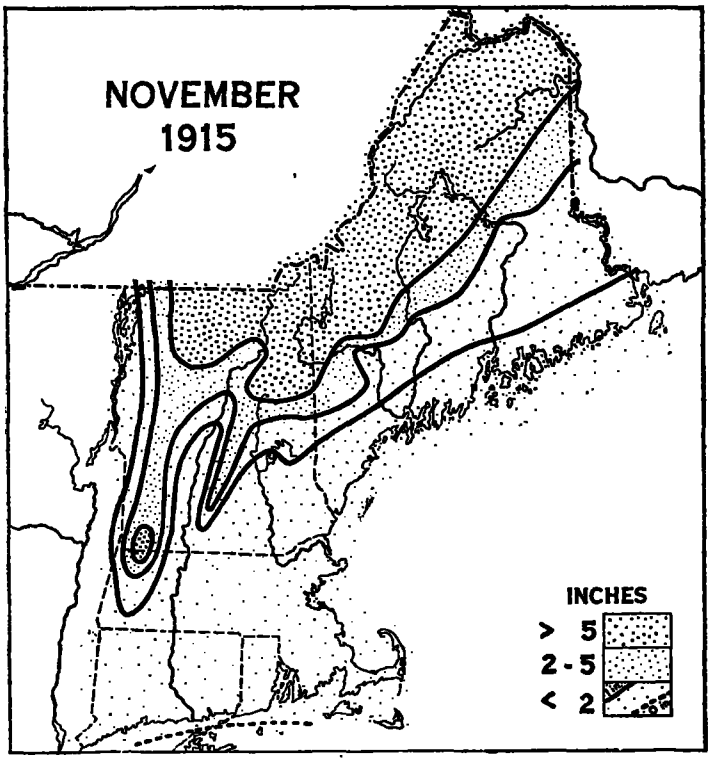

FIG. 4.—Snowfall of November, 1915. [Am. geogr. soc.]

November, 1915 (fig. 4).—The only snowstorm of importance was brought by a cyclone passing through New England. Thus there was appreciable snowfall only in the north; and the limits of this fall are rather sharply

[23] *Brooks, C. F.* MONTHLY WEATHER REVIEW, January, 1915, 43: 6-10 and Charts 19-22. Figs. 3, 5, 7, 9, 11, 12, and 14.

[24] *Brooks, C. F.* In MONTHLY WEATHER REVIEW, January 1915, 43: 2-4.

[25] *Hann, J. von.* Lehrbuch der Meteorologie, 3d ed. Leipzig, 1915, p. 112, or Poggendorff's Annalen der Physik, Jubelband 1874, p. 61.

[26] *Perley, Sidney.* Historic storms, etc., pp. 204-213.

defined. Light snows occurred on two other occasions. Throughout New England the snowfall was less than the average. In a similar way the snowfall of February 21–24, 1912, in the eastern United States shows a remarkably sharp line of demarcation between the heavy snowfall north of the cyclone track and the light snow on the south side.[27]

November, 1898 (*fig. 5*).—Most of the snowfall came on the 26th and 27th, during the "Portland storm." This was a very intense cyclone formed by the junction south of New England of a low-pressure area from the Great Lakes with one on the Atlantic coast. The heaviest snowfall of the month occurred in southern Connecticut, far enough west to be little affected by the warmth of the Atlantic, yet close enough to the cyclone center to have very heavy precipitation. The slight height of land in southeastern Massachusetts was sufficient to provoke

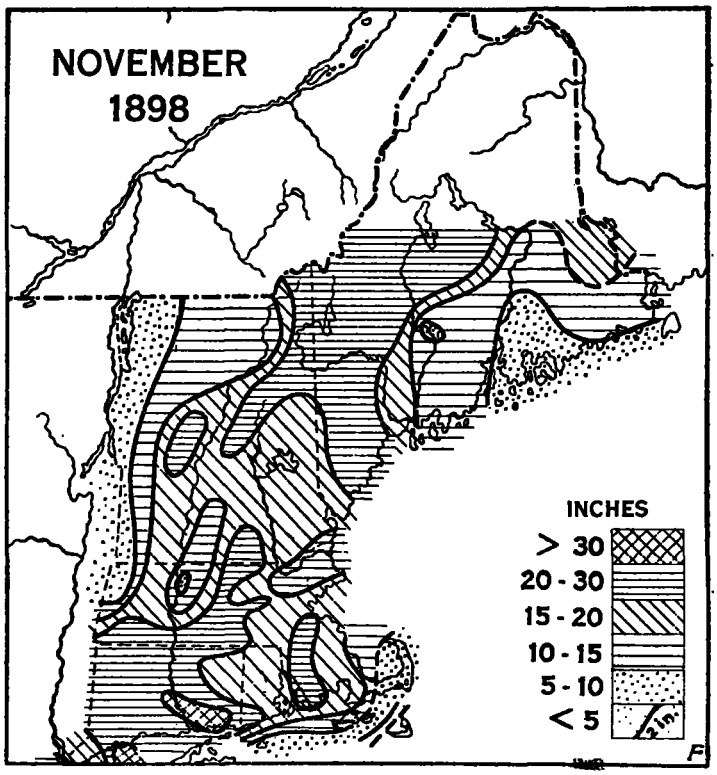

FIG. 5.—Snowfall of November, 1898.

heavier snowfall. Also, the distribution of snowfall in central New England shows strongly the control of exposure on the amount of snowfall. The effect of the ocean on temperature early in the season is shown in the following quotation taken from A. E. Sweetland's description of the storm of November 26–27, 1898: "The temperature line (thermograph) shows an abrupt fall (7° F.) at 2:10 a. m., when the wind changed from northeast to north; the temperature continued low until 10 a. m., when it rose as the wind veered to north-northeast, and it fell again at 4:05 p. m., when the wind changed to north-northwest." [28]

November mean snowfall, 1895–1915 (*fig. 6*).—November is characterized by small coastal amounts, as is the case with the two months just discussed.

[27] *Brooks, C. F., in* MONTHLY WEATHER REVIEW, June, 1914, 42: 325–330, maps of daily snowfall and discussion.
[28] *See* Bull., Blue Hill met'l obs'y, 1899, No. 2.

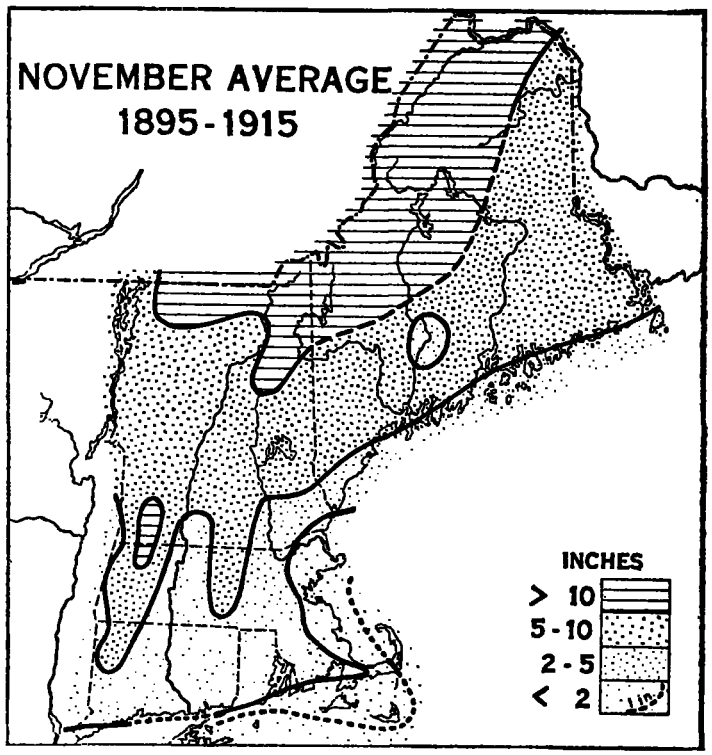

FIG. 6.—Mean snowfall in November, for 1895–1915. [Am. geogr. soc.]

December snowfalls.

December, 1915 (*fig. 7*).—Most of the December, 1915, cyclones with snow passed through New England, many of them entering from the south. The storm of December 13 was the most important, the depth of snowfall ranging from a foot and a half in western Massachusetts

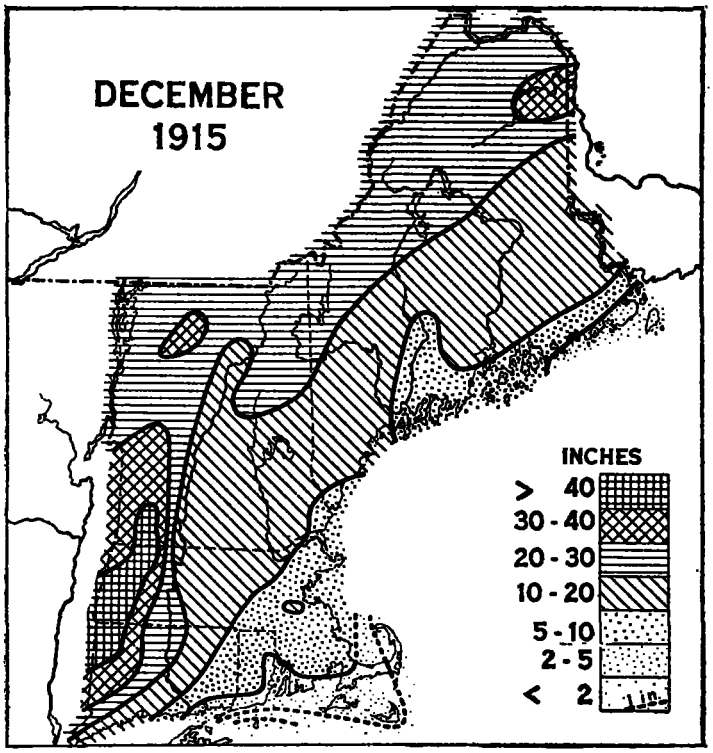

FIG. 7.—Snowfall of December, 1915. [Am. geogr. soc.]

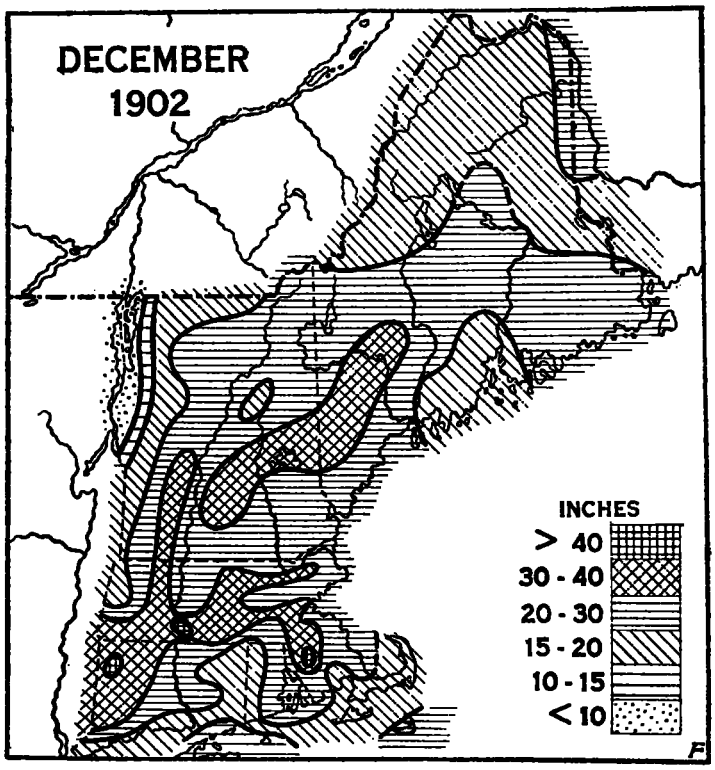

FIG. 8.—Snowfall of December, 1902.

and a foot at Springfield to less than an inch at Boston. In the south the heavy snow was very dense (density = 0.23, New Haven) and caused great damage to wires and trees; farther north, although the depth of snowfall was greater, the water content was less. The greatest amount of snow considered from the point of its water content is, therefore, not coincident with the greatest depth of snow on the ground. Similarly, the snowfall of March 11–14, 1888, had a density exceeding 0.2 on the immediate coast in the south, but the usual 0.1 in the interior.[29] As warm winds prevailed in eastern New England on December 13, 1915, the snowfall there was confined to the closing flurry of the storm.

December, 1902 (*fig. 8*).—In December, 1902, two cyclones with widespread snowfall passed, one south of, and the other across, New England. The effect of the warmth of the ocean is to be seen in the reduced snowfall all along the coast; and the diminution of cyclonic strength inland probably explains the well-defined northern limit of snowfall in excess of 30 inches in Vermont, New Hampshire, and Maine.

December mean, 1895–1915 (*fig. 9*).—As indicated by the maps for preceding months, the December snowfall lines still tend to run parallel to the coast.

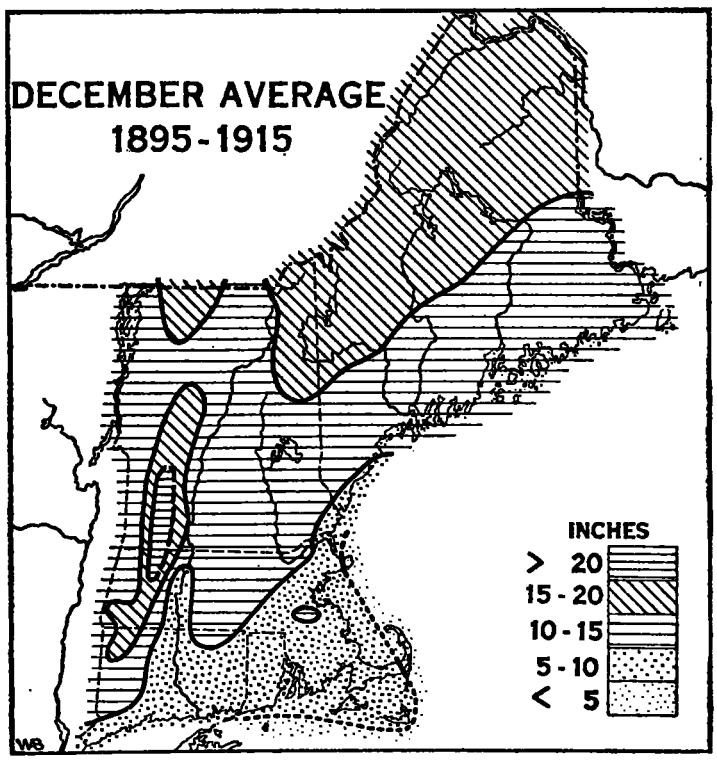

FIG. 9.—Mean snowfall in December, for 1895–1915. [Am. geogr. soc.]

January snowfalls.

January, 1916 (*fig. 10*).—All the snowy cyclones of this month passed on the north. On this account only in the north did snow occur in average amounts, as southerly winds do not favor snowfall. In the south at many places this January was one of the two or three least snowy Januarys in the 21 years.

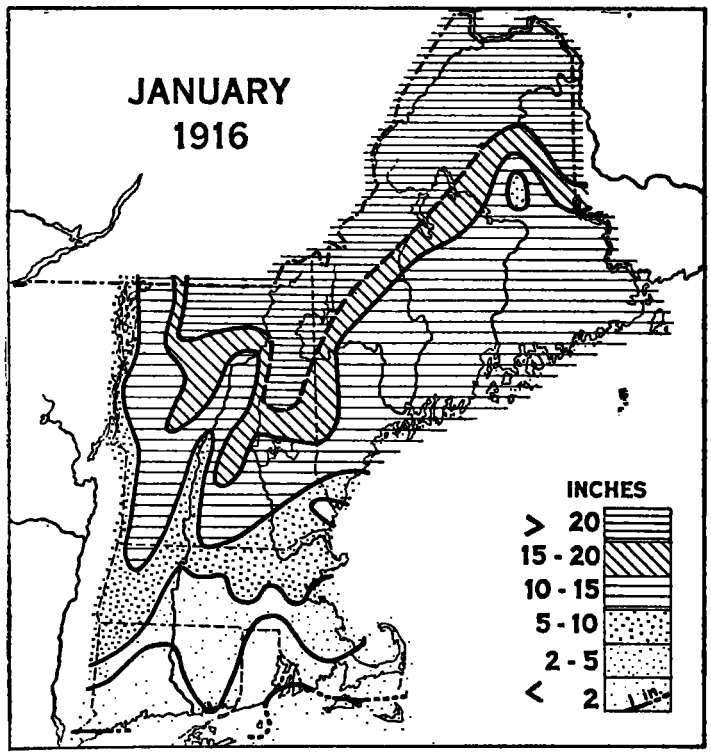

FIG. 10.—Snowfall of January, 1916. [Am. geogr. soc.]

January, 1904 (*fig. 11*).—On the 2d to 3d a cyclone accompanied by a very intense snowstorm passed south of New England. As with other single storms the snowfall was extreme only in part of New England. (See discussion of fig. 28, p. 283–4.)

[29] Winslow Upton *in* Amer. met'l jour., May, 1888, 5: 35, discusses variations in the density of the snow at different points in this one storm.

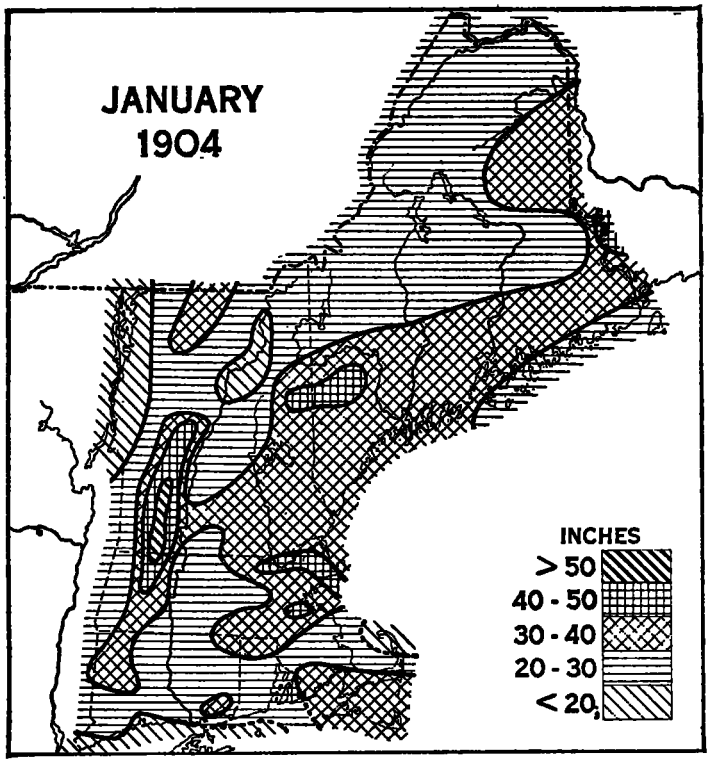

FIG. 11.—Snowfall of January, 1904. [Am. geogr. soc.]

January–February, 1898 (*fig. 12*).—An extraordinary snowstorm occurred January 31–February 1, 1898; the depth of snowfall being included in the January totals by some and in the February by others. Snowfall is heaviest where there is the most rapid condensation, with the air temperature near freezing at the ground. In these two months and in March, 1899, the conditions for snowfall were more favorable in the north than south, while in February, 1899, and January, 1904, the reverse was true. Note the snow shadows in the northern Connecticut and Champlain valleys.

January mean, 1896–1916 (*fig. 13*).—Topographic control on snowfall distribution is much stronger than that of latitude.

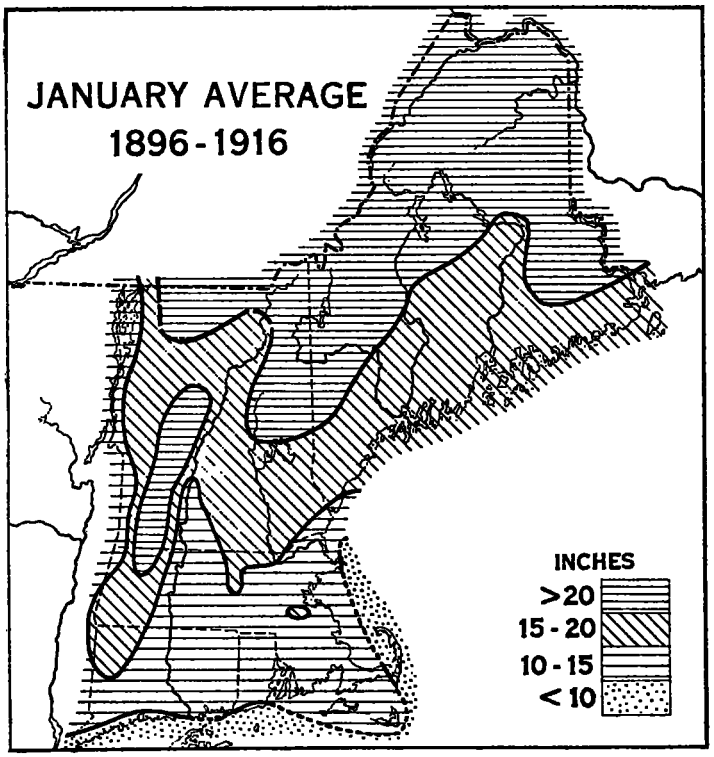

FIG. 13.—Mean snowfall in January, for 1896–1916. [Am. geogr. soc.]

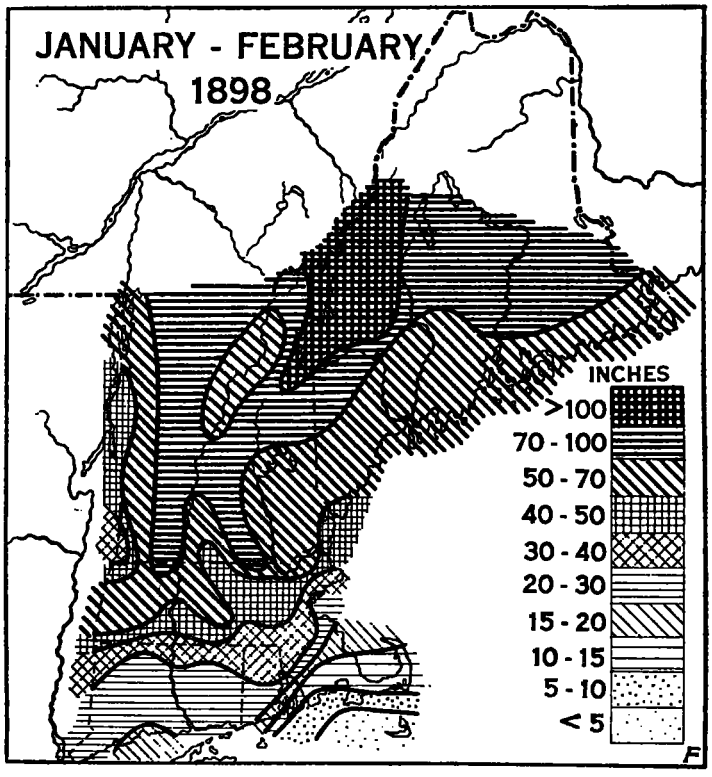

FIG. 12.—Snowfall of January and February, 1898.

February snowfalls.

February, 1916 (*fig. 14*).—As the storms passed through New England and on the south, and as the month was so cold that little of the precipitation fell as rain, the snowfall was rather evenly distributed throughout the region, with but little differences due to latitude or altitude. The effect of the ocean is apparent only in that there was much snowfall; snow-inhibiting temperatures were not experienced on the east coast as in November, December, and January.

February, 1899 (*fig. 15*).—Two moderate and one very intense snowstorm accompanied cyclones passing south of New England. The extreme coldness of the first half of this month, when most of the snow fell, made the heaviest snowfall come in the south and in the lower elevations. Thus topography is but slightly represented except in such regions of low relief as southeastern Massachusetts. The relatively small snowfall of Enosburg Falls (18 inches) and Jacksonville (25 inches) is noteworthy.

The usual heavy snowfall in southern Vermont is caused apparently by the passage of cool, moist winds over the mountains, favored by the eastward turn of the Connecticut Valley at that point, which hinders a farther southward flow of air. This ascent of the air leads to cooling by expansion which causes the increased precipitation. Table 4 brings out this effect. Brattleboro is freely exposed to the northeast winds sweeping down the

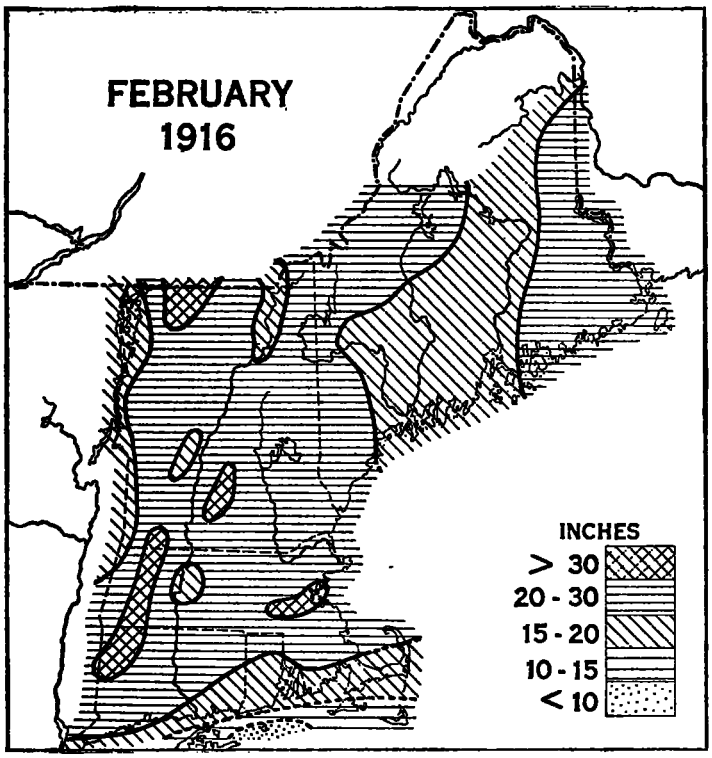

FIG. 14.—Snowfall of February, 1916. [Am. geogr. soc.]

river and is located at the turn. Jacksonville is on the highlands on the west, but east of the divide. In very snowy (January and February, 1898) or very cold months (February, 1899) snowfall at Brattleboro may equal or even exceed that of Jacksonville. Vernon is around the bend of the river and so its snowfall is considerably less.

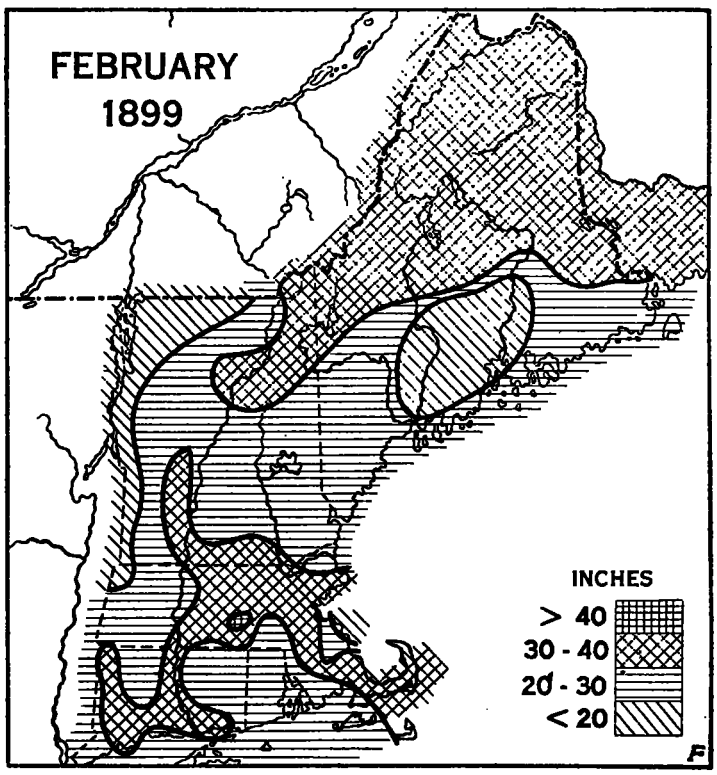

FIG. 15.—Snowfall of February, 1899.

Higher than Jacksonville the snowfall is apparently heaviest. Monroe, Mass., on Hoosac Mountain, and Somerset, Vt., west of Jacksonville, have too short records to prove this.

TABLE 4.—*Altitude, exposure, and snowfall (to nearest inch) in southern Vermont.*

Locality.	Altitude above sea level.	Average 1896-1900.	January and February, 1898.	February, 1899.	Season.	
					1895-96.	1915-16.
	Feet.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Brattleboro	335	97	78	35	79	.....
Jacksonville	1,000	106	74	25	113	.....
Vernon	310	76	62	30	60	86
Monroe	1,860	.....	.....	.....	126	.....
Somerset	2,096	.....	.....	.....	.....	161
Williamstown, Mass	711	.....	(*)	20	41	119

* Bennington had 38 inches.

In northern New England west-wind snowfall is encountered in large amounts where winds from the St. Lawrence Valley rise to cross the mountains, as, for instance, at Enosburg Falls, Vt., with an average seasonal snowfall of 97 inches, and at Bethlehem, N. H., with 85 inches. In February, 1899, there was too little moisture in the air to allow the usual excess of snowfall in these places.

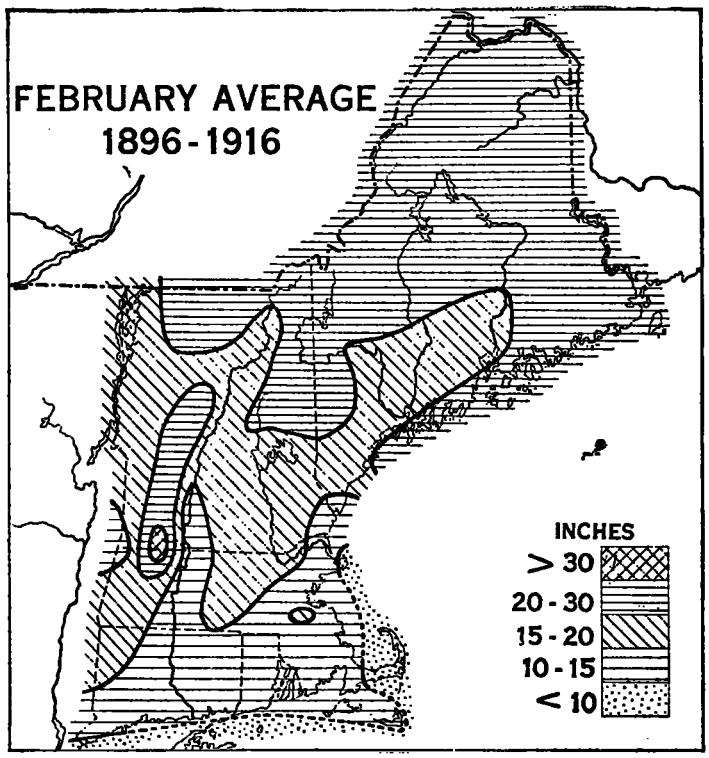

FIG. 16.—Mean snowfall of February, for 1896-1916. [Am. geogr. soc.]

February mean, 1896–1916 (fig. 16).—The ocean being cold by February it is possible for heavy snowfall to occur on the coast, especially in Maine. This is the month of maximum snowfall throughout New England. Nowhere is the winter generally so cold that there is a midwinter reduction in snowfall due to the reduced moisture capacity of cold air. There is a suggestion of such an effect in Vermont, where at most stations the heaviest snowfall in any month has come in March (see February, 1899).

March snowfalls.

March, 1916 (fig. 17).—Except in the southeast New England was entirely snow-covered from early February to the end of March, 1916. At New Haven the ground was more than half covered from February 3 to March 28 and for the whole season more than half covered with snow on 91 days. On March 21 the depth of snow in eastern Massachusetts exceeded 20 inches and in the western part and New York averaged 3 feet, with drifts reported as high as 15 feet. As mentioned on page 272, the low temperatures (Blue Hill, Mass., temperature Mar. 1–21 was 11.1 degrees below normal) favored by this snow cover tended to aid the development of anticyclones and so to make approaching cyclones pass south of New England. Furthermore, the marked warmth of the near-by portion of the Gulf Stream tended to strengthen

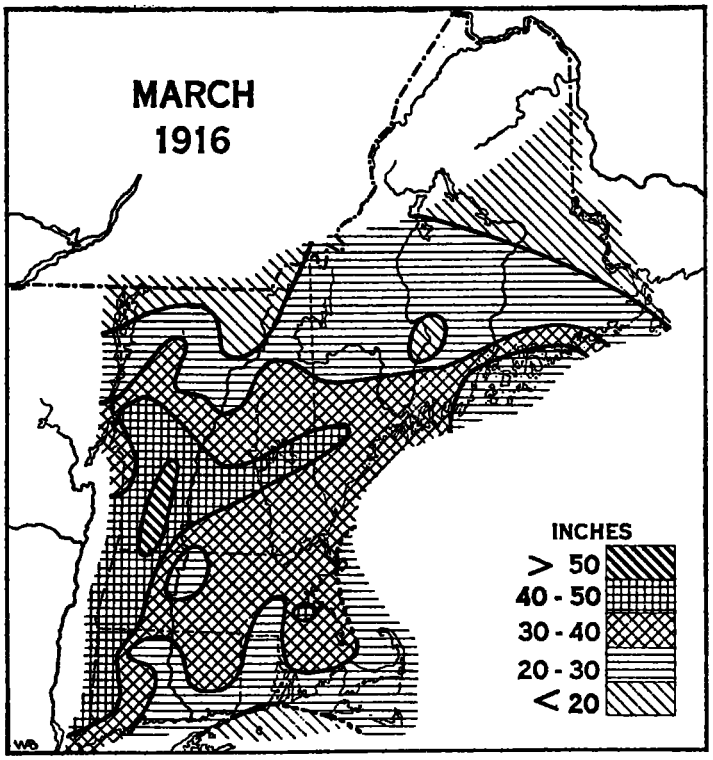

FIG. 17.—Snowfall of March, 1916. [Am. geogr. soc.]

the cyclones. Thus the saying "the more snow the more snow" is true within limits. Snow fell on 16 days at Blue Hill and on 12 in New Haven during the first 21 days of March. In northern New England the snowfall was normal, but throughout the southern portion it was excessive. However, in some of the area the snowfall of March, 1888, was greater. At most points on the east coast the snowfall was heavier than at a short distance inland, as is to be expected in March. The extremes of the western mountains were due to the topographically enforced rise of the moist air. As in February, most of the precipitation of the month was in the form of snow, hence there was more snowfall in southern New England than in northern because of the greater supply of moisture.

March, 1899 (fig. 18).—A moderate snowstorm accompanied the passage of a cyclone north of New England; two heavy snowstorms came with cyclones on the south, and one heavy snowstorm was brought by a cyclone passing through New England. In the north the usual heavy snowfall on the east of the divides and the lighter snow on the west is apparent. In the extreme north, however, west-slope snowfall was very great: Enosburg Falls, 49 inches; Bethlehem, N. H., 46 inches. The trend of the coast has but little effect on the direction of the snowfall lines, since the ocean is cold in March.

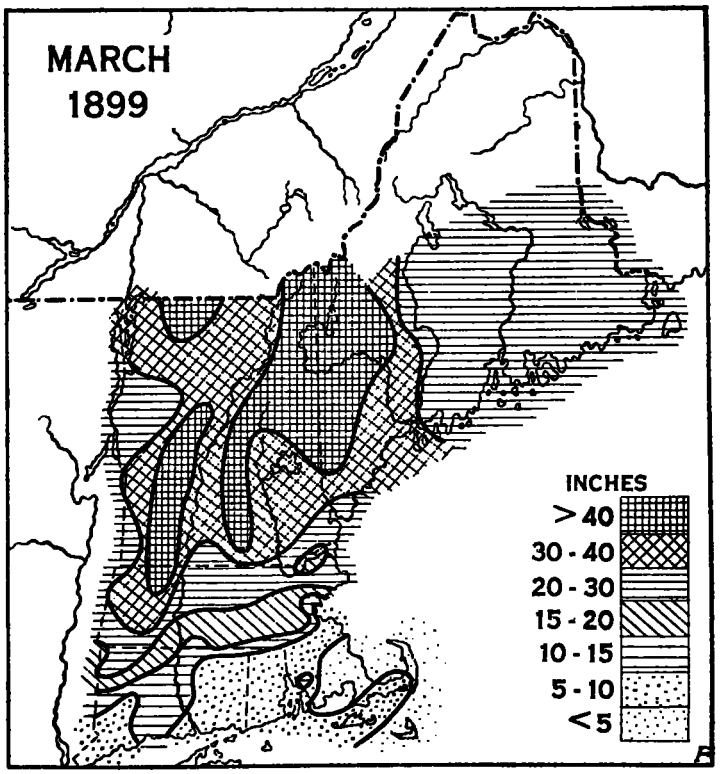

FIG. 18.—Snowfall of March, 1899.

March mean, 1896–1916 (fig. 19).—The snowfall is almost the same as that of December, except on the coast of Maine. The coast snowfall in March is heavier relative to that of the interior than in December.

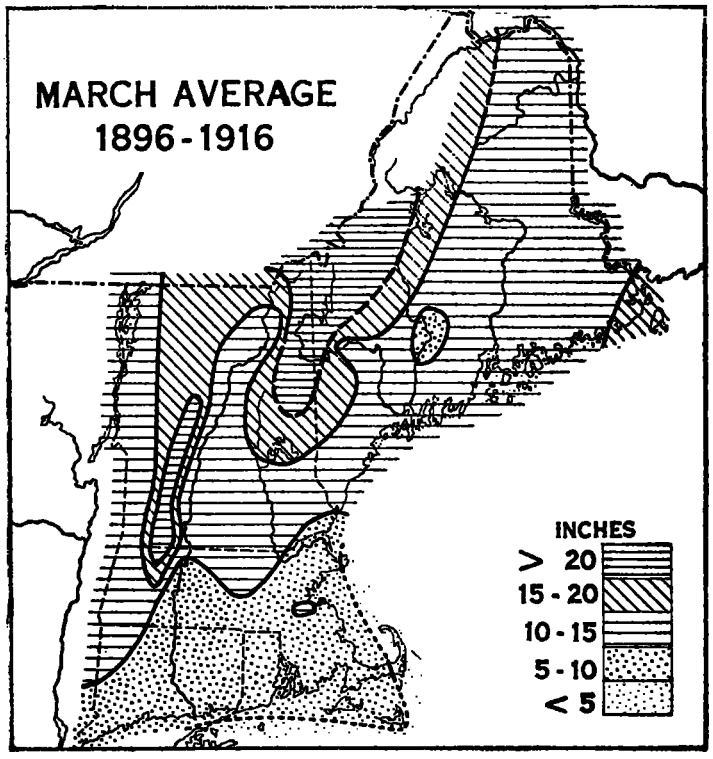

FIG. 19.—Mean snowfall of March, for 1896–1916. [Am. geogr. soc.]

Maximum snowfall in any month.

The maximum snowfall in any month (fig. 20) equals about half the snowfall of the snowiest season in southern, and one-third in northern, New England. In the north, January and March were the months with maximum snowfall, February being third; in the south, this order was February, January, and March; and for New England as a whole, January, February, and March. Although 21 years is too short a period to give these extremes much weight, they seem to indicate to some extent the effect of February cold. In the north, on account of the reduced moisture capacity of the atmosphere it apparently can not snow so hard in February as in January or March, even though the highest mean is in February. In the south, where it is usually too warm for much snow, the month of greatest snowfall comes late in winter when temperatures accompanying "northeast storms" are most likely to be below freezing.

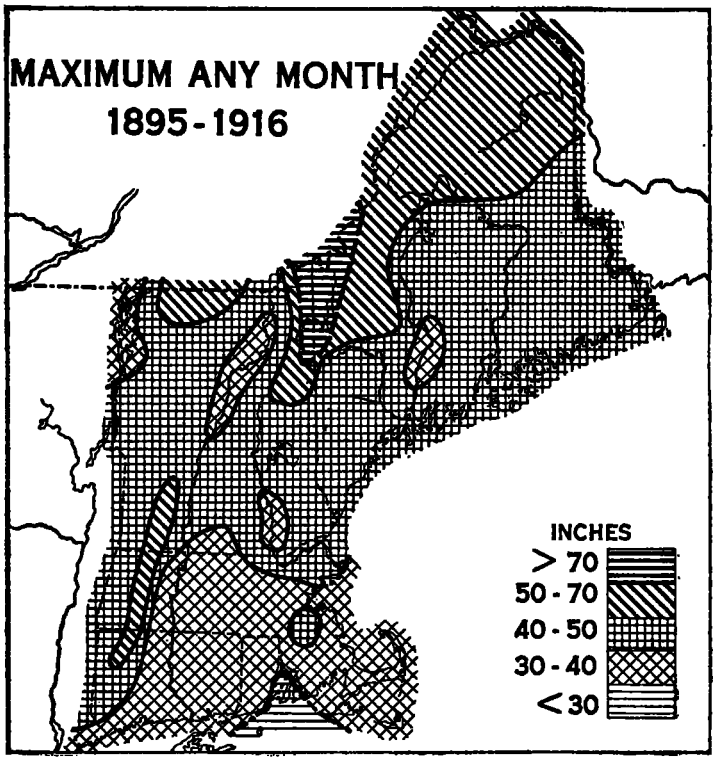

FIG. 20.—Maximum snowfall in any month, for 1895–1916. [Am. geogr. soc.]

April snowfalls.

April, 1916 (fig. 21).—Since the snow cover of March lasted into April in northern New England, the same condition of southern cyclones was favored. As was to be expected, the snowfall of the extreme northwest was but little above the average. The east coast snowstorm of April 28 was extraordinary for so late in the season. On Blue Hill the 8 inches of dense snow (water content, 1.68 inches) lasted till noon the 29th, on which day the temperature reached 61°.

April, 1907 (fig. 22).—At the close of a decidedly snowy winter an intense cyclone lingered for a day south of New England, and joined another strong cyclone from Lake Huron; the center then passed just north of Nantucket. On-shore winds produced particularly heavy snowfall on the coast of Maine. The topographic control of snowfall distribution, or, perhaps more properly, the distribution of that which did not melt on striking the ground, is

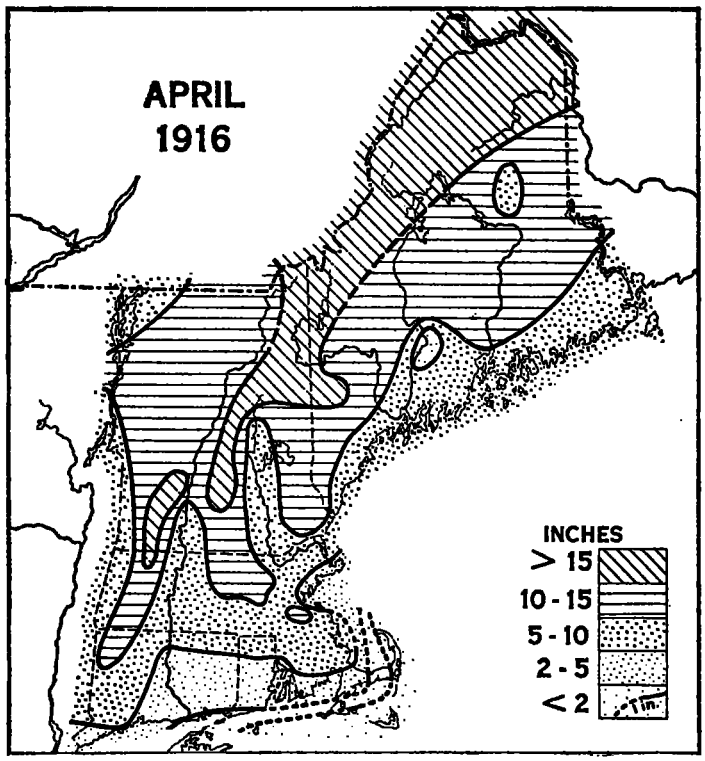

FIG. 21.—Snowfall of April, 1916. [Am. geogr. soc.]

marked. Nantucket, on the warm side of the storm, did not get much snow (1 inch). The record for April snowfall was established over almost all New England.

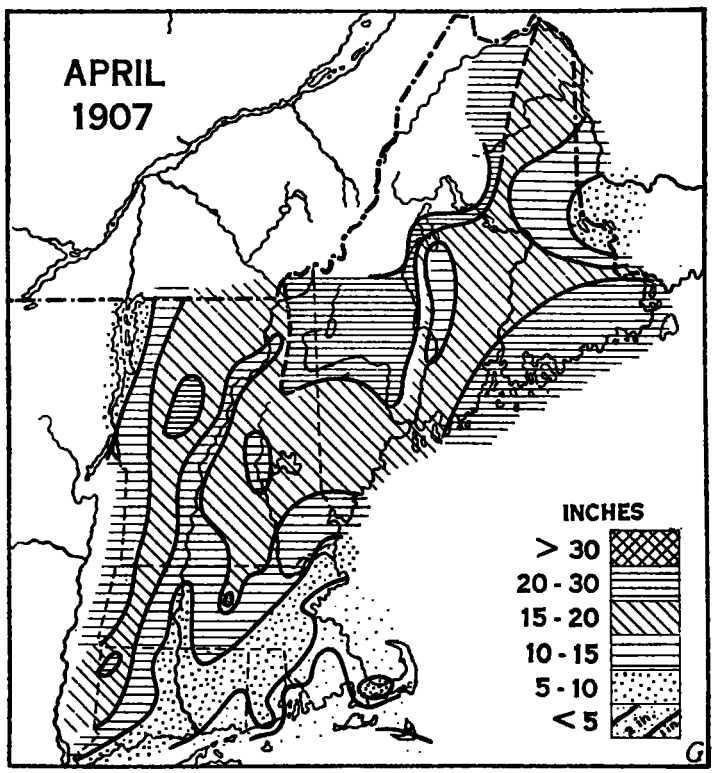

FIG. 22.—Snowfall of April, 1907.

April mean, 1896–1916 (fig. 23).—On the east coast April snowfall exceeds that of November; elsewhere November snowfall is in the lead. In the northwestern half of Vermont the November snowfall is double that of

April. While temperatures in both months are low enough for snow, there is less tendency to precipitation in April because the winds from the water surfaces tend to become warmer on land, rather than colder, as is the case in November. At Enosburg Falls, on the west slope in the extreme north, the maximum snowfall in any November was 51 inches, while the April maximum was but 11. Many of the snow-bearing winds for this station came from the Lakes Region to the west and northwest. On the other hand, if in April the ground is covered with snow, heavy snowfall may occur, particularly on the coast, for the land is then cold relative to the water. Thus at Eastport the mean snowfall for April (9 inches) is almost twice that of Enosburg Falls (5 inches).

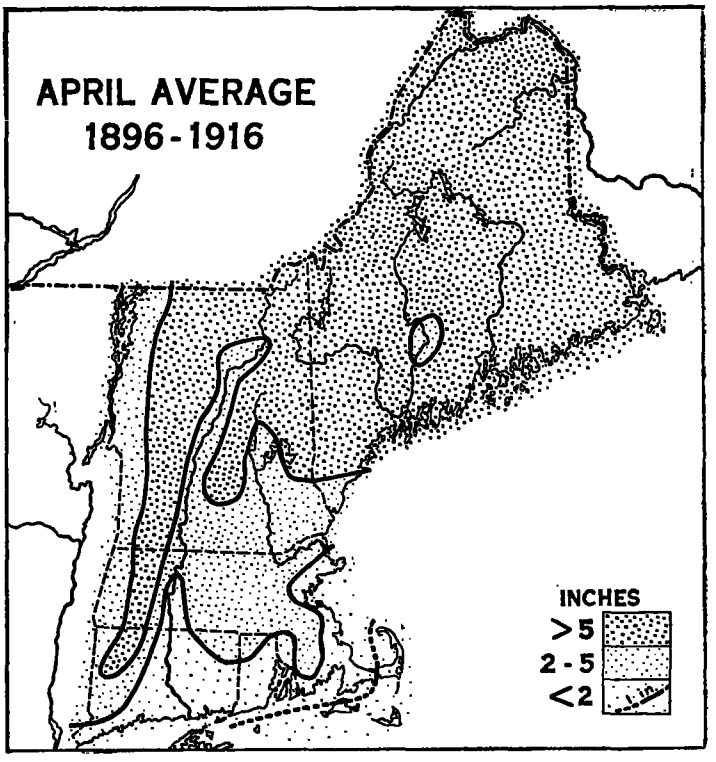

FIG. 23.—Mean snowfall of April, for 1896–1916. [Am. geogr. soc.]

In April the measured depth of snowfall seems to be more dependent on altitude than in any other month. This may be because the surface ground temperatures are above freezing, at least in the lowlands. So here, the snow may melt immediately on touching the ground, although it is accumulating on the adjacent hills. On April 28, 1916, but 2 inches of snow collected on the ground in the Boston Basin only a few hundred feet below Blue Hill, where the depth was 8 inches. A similar phenomenon occurs in November, but because of the effect of the warm ocean it is not so noticeable. In April, on the other hand, the ocean may be said to be neutral and so the altitude differences are not complicated.

Seasonal snowfalls.

Season, 1915–16 (fig. 24).—The season was characterized by very frequent snowfall, especially in February and March. Only a few storms stand out as extraordinary. Taking the season as a whole, there were 8 snowy cyclones passing to the north, 11 passing across, and 11 to the south of New England. Of the 11 cyclones bringing heavy snowfall, 4 passed through New England and the other 7 went by on the south. Three out of the four which went through New England occurred in December, leaving southeastern New England comparatively free of snow. The southern cyclones of late winter, however, made up for this early lack of snow. For the season, the result was an extraordinary snowfall, particularly in the

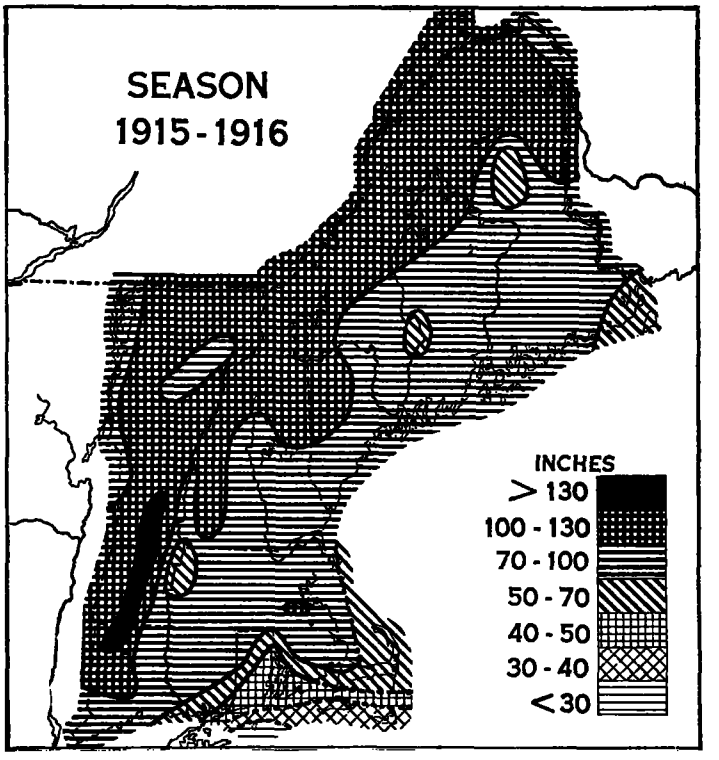

FIG. 24.—Seasonal snowfall for 1915–16. [Am. geogr. soc.]

west. The topographic control of the distribution of snowfall is patent. Especially interesting is the heavy snowfall of the Champlain Valley, which normally is in the snow shadow either of the Adirondacks or of the Green Mountains. In this season there was north wind with the snowfall. This produced heavy snows on the west side of the Green Mountains, giving records of 123 inches at Cornwall and 119 inches at Williamstown. Note the snow shadows east of the mountains. The 97 inches recorded at Springfield, Mass., may be due to the turn of the Connecticut River just below Springfield, which obstructs the clear sweep of a north-northwest wind down the valley in much the same way as at Brattleboro (see discussion of February, 1899, map p. 279).

TABLE 5.—*Contemporaneous snowfall differences on opposite sides of a mountain range.*

Station.	Average snowfall.	Length of record.	1895–96.	1915–16.
	Inches.	*Years.*	*Inches.*	*Inches.*
WEST SIDE.				
Williamstown, Mass	54	20	41	119
Cornwall, Vt	70	14	a 55	123
EAST SIDE.				
Vernon, Vt	68	8	60	86
Northfield, Mass	82	21	90	93

a 8 inches interpolated.

Season 1898–99 (fig. 25).—Many snow-bearing cyclones traversed New England or passed south or north. As a result the map presents an intensified picture of the average seasonal snowfall.

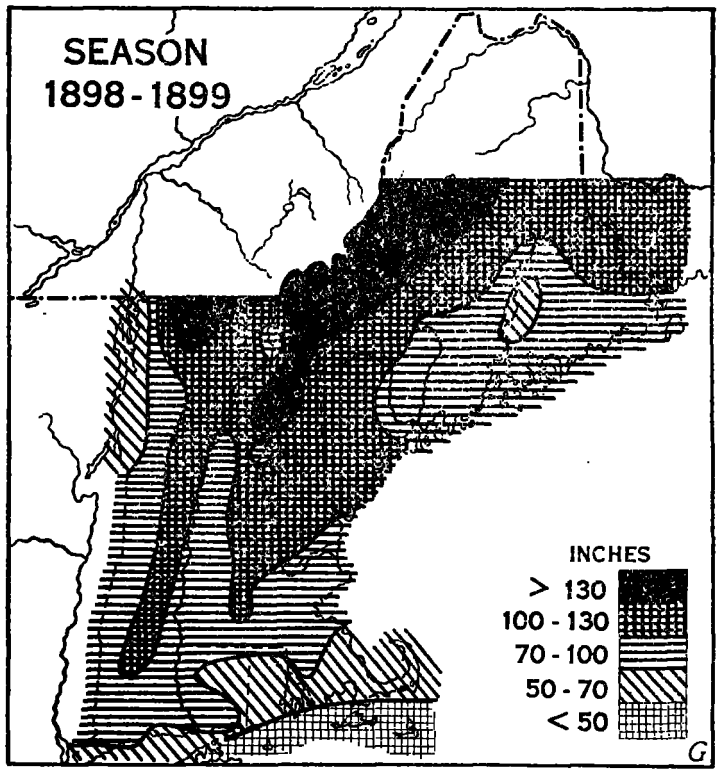

FIG. 25.—Seasonal snowfall for 1898–99.

Season, 1900–1901 (fig. 26).—Only one cyclone of this winter brought intense snowfall over any considerable area of New England. This passed through the region.

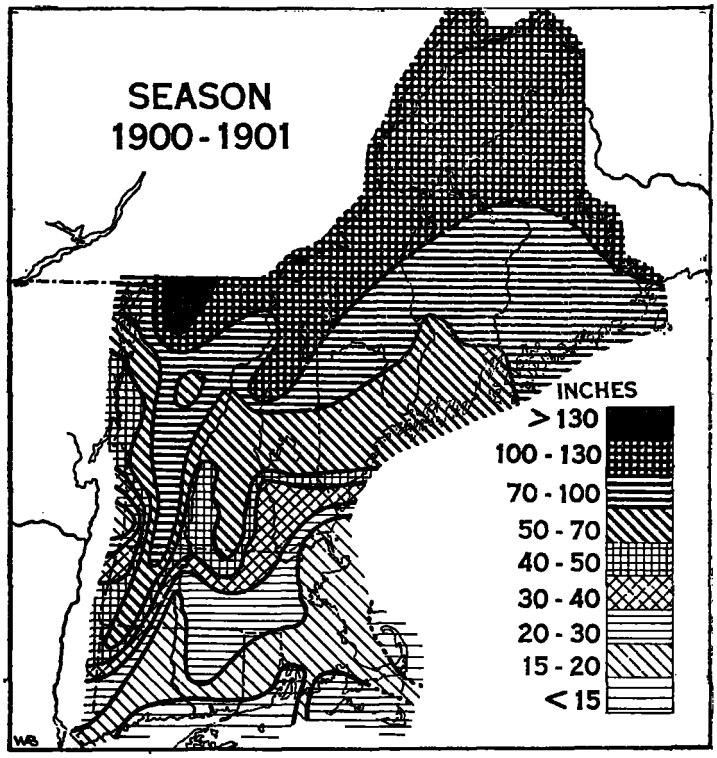

FIG. 26.—Seasonal snowfall for 1900–1901. [Am. geogr. soc.]

The west winds, following the passage of this and other cyclones, were responsible for the heavy snows at Enosburg Falls (192 inches). At Quebec snow occurred with southwest, west, and northwest winds 17 times at 8 a. m., in the four months, December, 1900, to March, 1901, while the average for these months, 1895–1913, is but 7, as shown on the weather maps. This same winter was that in which the maximum of 334 inches of snow was reported at Adams, N. Y., at the east end of Lake Ontario. In many places of southern New England the winter was that with the least snowfall in 21 years (cf. conditions of January, 1916, or of November, 1915). The snowfall at Burlington, Vt., was but slightly above the average, and that of Cornwall, a little farther south and still more in the "snow shadow" of the Adirondacks, was but 45 inches or only 4 inches above the minimum in 14 years of record. Under ordinary conditions, however, the snowfall at Cornwall is above the median in the same seasons that that at Enosburg Falls is in excess, and vice versa.

Season, 1906–7 (fig. 27).—Four very heavy snowstorms occurred, two accompanying cyclones passing south of New England and two going through. Eastport is so placed that it got heavy snowfall all through the winter.

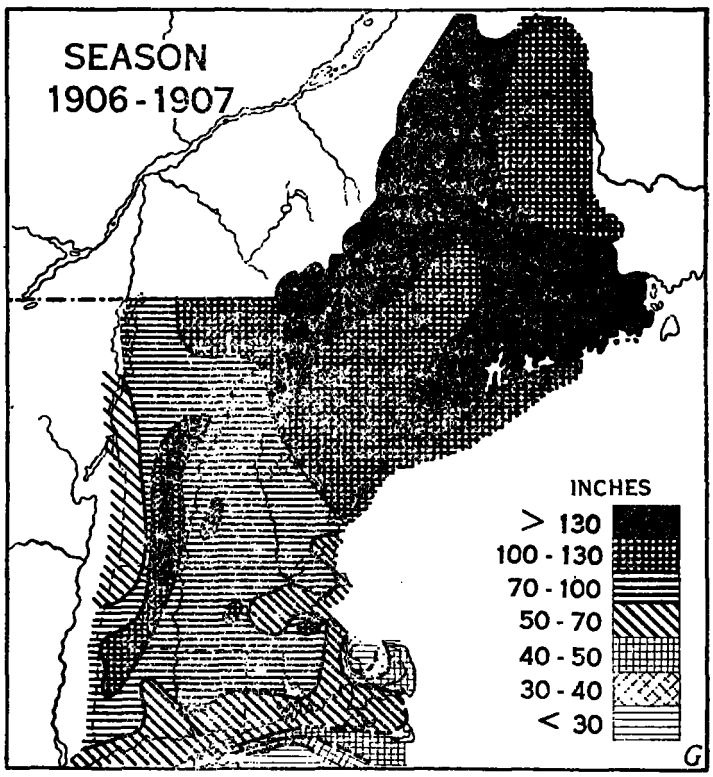

FIG. 27.—Seasonal snowfall for 1906–7.

Greatest snowfall in any season, 1895–1916 (fig. 28).—As the snowfall on the east side of the Green Mountains occurs largely with winds from the Atlantic, it is significant that the northern limit of 130 inches of snowfall in these mountains is directly opposite the southern limit of 130 inches in the White Mountains. The maximum of 82 inches at Nantucket is a little greater than that of most places in the southeastern half of the area including Massachusetts, Connecticut, and Rhode Island. This excess came in January, 1904, when Nantucket was surrounded with ice—giving it the character of the cold land to the north. The heavier snowfall came as a result of being nearer the cen-

ters of the passing cyclones, particularly that of January 2–3. The small snowfall of Block Island seems to show the effect of warmer water and of the land protection during northeast storms. The snowfall of January, 1904, may be taken as an example (fig. 11). In the southeast the distribution was as follows: Nantucket, 40 inches; Fall River, 33; New London, 33; Hyannis, 31; Plymouth, 26; Narragansett Pier, 22; Provincetown, 18; Block Island, 14 inches.

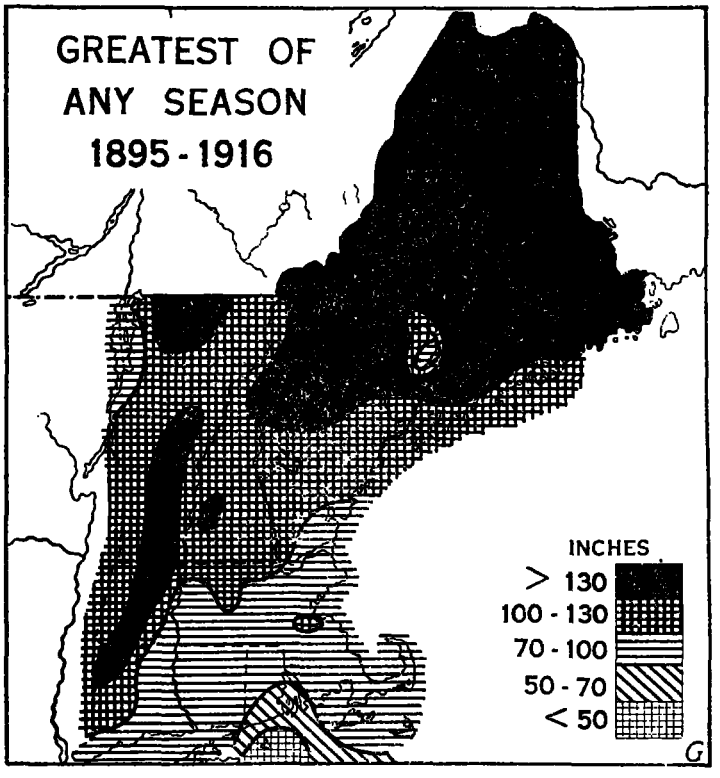

FIG. 28.—Greatest seasonal snowfall, for 1895 to 1916, inclusive.

TABLE 6.—*Monthly snowfalls during seasons with more than 150 inches.*

Station.	Season.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Total.
		In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Easport, Me	1906–7	3	14	35	36	45	29	26	5	*192
Enosburg Falls, Vt	1900–1	0	34	33	49	36	38	2	0	192
Do	1901–2	0	51	29	26	49	9	3	2	169
Jacksonville, Vt	1903–4	T	5	38	67	23	9	16	0	*159
Do	1904–5	1	14	43	61	44	13	2	T	178
Do	1909–10	T	7	42	47	80	0	3	0	179
Somerset, Vt	1915–16	0	8	42	12	30	54	15	0	161
Alstead, N. H	1915–16	0	3	29	15	41	44	19	0	151

* The dropping of fractions in monthly totals makes the sum of the months differ from the seasonal totals by 1 inch.

Least snowfall in any season, 1895–1916 (fig. 29).—The minimum snowfall is, in general, about half as far below the average as the maximum is above, although in some places the average is halfway between the two. Thus, in most seasons the snowfall is below the average. In the north the minimum snowfall tends to come in cold or dry seasons. There is, then, but little topographic variation, for lowland temperatures are not high enough to melt some of the falling snow, or there is a lack of sufficient moisture to produce heavier precipitation on mountains than lowlands. (For the effect of a very cold month, see fig. 15, February, 1899.) In the south, on the contrary, cold winters are also snowy winters. So with the minimum occurring in warm winter seasons, differences in altitude are productive of marked snowfall differences, as is usually the case in April (see discussion of fig. 23).

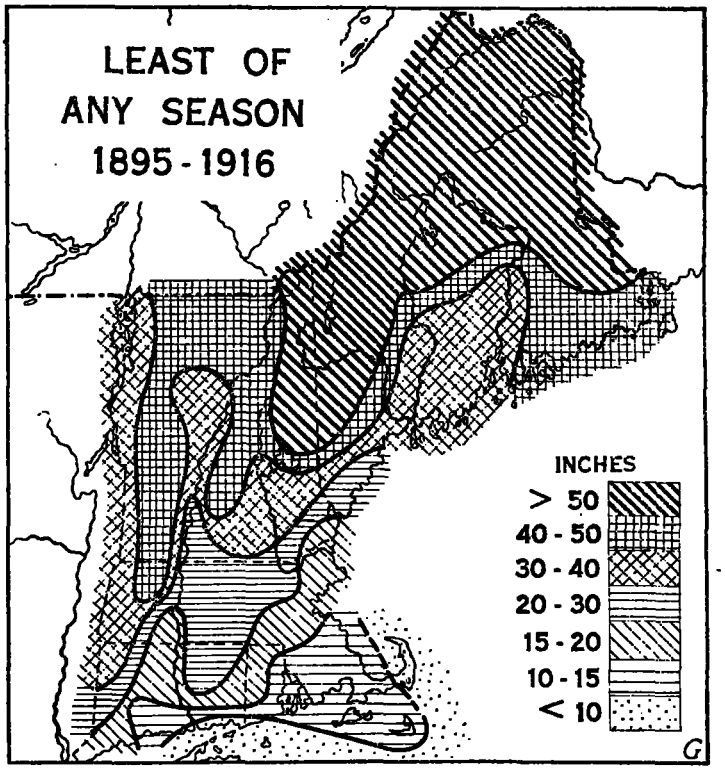

FIG. 29.—Least seasonal snowfall, 1895 to 1916, inclusive.

At Eastport, Me., and Enosburg Falls, Vt., the greatest and least seasonal snowfalls in the 21 years were the same. Yet the one is marine in location and the other is far inland on the west side of a mountain. Table 7 brings out the differences, however. The marine influence at Eastport is shown in the smaller variations and monthly extremes.

TABLE 7.—*Eastport, Me., and Enosburg Falls, Vt., snowfalls 1895–1916, compared.*

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Season.
Average snowfall:	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Eastport (53 ft.)	0	0.3	6	14	19	20	16	9	0.3	0	84
Enosburg Falls (436 ft.)	0	0.3	12	18	21	24	17	5	0.1	T.	[a] 97
Minimum snowfall: [b]											
Eastport	0	0	T.	4	6	9	2	0	0	0	45
Enosburg Falls	0	0	2	4	6	6	0	0.5	0	0	44
Maximum snowfall: [b]											
Eastport	0	3	15	35	36	45	33	26	5	0	192
Enosburg Falls	0	3	51	40	49	49	49	11	2	T.	192

[a] Nov., 1899, missing. [b] Months not all in the same season.

Mean departures of seasonal totals from the average: Eastport, 18 inches; Enosburg Falls, 25 inches.

Only in such places as the protected Champlain and upper Connecticut Valleys is the extreme range of seasonal snowfall less than the average seasonal total; in parts of New England it is double the average. This large range of 60 to 100 inches in general, but with extremes of 37 and 148, is an indication of what excessive snow a number of strong cyclones may bring.

Seasonal average, 1895–1916 (fig. 30).—The great snowfall of the exposed highlands, the local snow shadows and the relatively light snowfall of the coast show that the features apparent in the maps of individual seasons have sufficient repetition to be shown as usual phenomena. Only on the coldest part of the coast (Maine) does the heavy shore snowfall of the late winter make the total greater than that a short distance inland.

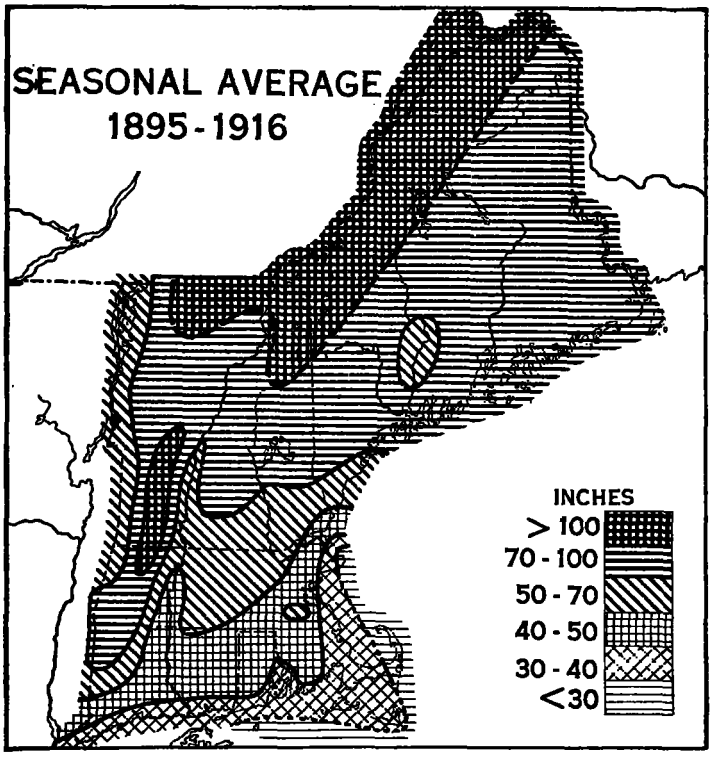

FIG. 30.—Mean seasonal snowfall, for 1895–1916. [Am. geogr. soc.]

SUMMARY.

Air temperature is probably the first factor in determining snowfall. The latitude and altitude differences in temperature cause the heaviest snowfall so far as controlled by temperature to be in the north and on the highlands. Similarly, the most snow tends to come in the coldest month, except in the north in winters colder than usual. Although January is as cold as February, the snow-bearing winds of February are the colder and so the snowier. The warmth of the coast is less favorable for snowfall than the coldness of the interior.

Without precipitation, however, there can be no snowfall. Precipitation is greatest on highlands near or facing bodies of water and near the paths of cyclone centers. The seasonal variations are small in amount.

Wind direction during precipitation is the third important factor controlling snowfall. Windward slopes of mountains and leeward shores tend to have the most precipitation. Combine the effects of these three factors, and the distribution of snowfall in New England may be explained. The highlands are the snowiest; for they are cold, moist, and windy. Particularly snowy are those slopes which are openly exposed to easterly or northeasterly winds or, as in the north, to the westerly winds from the Great Lakes. The intermontane valleys have less snowfall because of the higher temperature, less precipitation, and less exposure. In the coastal region there is plenty of precipitation, and open exposure, for the most part, so that the snowfall depends chiefly on the temperatures. Thus in early winter the snowfall is less than in late winter; in early winter the snowfall on the immediate coast is less than that inland, allowing for topographic influences; and in late winter the snowfall of the coast is the heavier. As New England is the focus of most of the cyclones which cross the United States or come up the east coast, there are chances for wide variations in their paths. On this account all parts of New England are crossed by numerous cyclones. As the strongest ones, however, pass south of New England or cross its southeastern portion, this section from time to time experiences extraordinary snowstorms, a great characteristic of the climate of New England.

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THE COLD SPRING OF 1917.

By PRESTON C. DAY, Climatologist and Chief of Division.

[Dated: Washington, D. C., July 3, 1917.]

Beginning about April 24, and continuing to the middle of May, a period of three weeks, cold weather for the season of the year persisted to an unusual degree in nearly all portions of the country. The daily temperatures for the period, as shown by figure 1, were almost continuously below the normal, and the mean for the 21 days was likewise below the normal at practically every Weather Bureau station in the United States. The deficiencies for the period ranged from about 3 degrees per day near all the border lines, to 9 degrees over the interior districts, reaching extreme values as great as 12 degrees per day at local points from southeastern Wyoming to central Ohio.

After a brief interval of about one week with temperatures generally, though not materially, above normal over most districts east of the Rocky Mountains, another period of cold set in about May 22 and continued with but few interruptions until the end of the second decade of June, a period of about four weeks. In duration, amount of the departure below the normal temperature, and at times in area covered, this second cold period exceeded that first mentioned. For this period the mean temperature was below the normal over all portions of the country save along the Gulf and South Atlantic coasts, and at a few points in the far Northwest. Over all the interior portions the weather for these four weeks was almost continuously cold, the mean temperature ranging 6 to 8 degrees below the normal, with individual short periods having temperatures 10 to 20 degrees or more, below. The departures from the normal temperature for this period as a whole, are shown by figure 2.

Considering the month of May in its entirety the temperature averaged below normal in every portion where full reporting stations of the Bureau are located, save in extreme northwest Montana where a single station showed an excess of but a few tenths of a degree. This exception is probably due to an inadequate record for the normal.

An examination of previous records for May since 1872, the earliest year yielding Weather Bureau observations from coast to coast, does not disclose another instance when the average temperature for that month was so universally below the normal. In other years the negative departures over local areas, in a few cases, have been equal to or slightly greater than those for May, 1917, but in no case has the area covered equaled that of the month under discussion.